SEISMIC DESIGN FOR REINFORCED CONCRETE HOSPITAL BUILDING INFLUENCED BY SOIL TYPE AND GRADE OF CONCRETE

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Thesis submitted in partial fulfillment of the requirements
for the award of the
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

MAY 2019

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful Alhamdulillah, all praises to Allah for the strengths and His blessing in completing this thesis. Special appreciation goes to my supervisor, Dr. Mohd Irwan Adiyanto, for his supervision and constant support. His invaluable help of constructive comments and suggestions throughout the final year project have contributed to the success of this research. Thank you for giving me a piece of chance to perform in completion process of my final year project very well.

Getting through my dissertation required more than academic support, and I have many, many people to thank for listening to and, at times, having to tolerate me over the past four years. I cannot begin to express my gratitude and appreciation for their friendship. Sincere thanks to all my friends especially Ummu, Hazwani, Azlina, Izzati, Hanis and others for their kindness and moral support during my study. Thanks for the friendship and memories.

Last but not least, my deepest gratitude goes to my beloved parents; Mr. Mazlan B. Mohd and Mrs. Midah Bt. Abdullah and also to my sister and brothers for their endless love, prayers and encouragement. To those who indirectly contributed in this research, your kindness means a lot to me. Thank you very much.

ABSTRAK

Reka bentuk seismik adalah sangat maju, kompleks dan dikawal ketat oleh kod dan piawaian. Kod seismik mempersembahkan kriteria untuk reka bentuk dan pembinaan struktur baru tertakluk kepada gerakan gempa bumi untuk meminimumkan kadar kehilangan nyawa dan meningkatkan keupayaan bangunan penting seperti bangunan hospital untuk berfungsi selepas gempa bumi. Kaedah semasa di Malaysia tidak mempraktikan reka bentuk seismik dalam merancang sesebuah bangunan. Kemudahan kesihatan terutamanya hospital terdedah kepada risiko kerosakan yang serius dan kehilangan nyawa semasa gempa bumi, jika tidak dibina dengan sewajarnya. Memandangkan bangunan hospital adalah salah satu struktur yang penting untuk keperluan awam sebagai institusi perubatan dan perlu menampung banyak orang, ia seharusnya dapat menahan beban seismik apabila berlaku gempa bumi dan ia berkait rapat dengan kekuatan struktur. Oleh itu, kajian ini menyiasat jumlah pengukuhan keluli bagi bangunan hospital konkrit bertetulang dengan reka bentuk seismik. Analisis dilakukan dengan menggunakan tiga jenis tanah yang berbeza dan dua jenis gred konkrit yang berbeza. Terdapat lapan model 8 tingkat bangunan hospital yang digunakan untuk analisis yang direka berdasarkan Eurocode 8 dan dijalankan dengan menggunakan perisian Tekla Structure Design. Berdasarkan keputusan, dapat disimpulkan bahawa berat gelang besi untuk elemen rasuk dan kolom meningkat sekitar 2.3% hingga 10.8% jika dibandingkan dengan reka bentuk bukan seismik.apabila bangunan itu dibina menggunakan gred konkrit G30. Sementara itu, untuk pengaruh gred konkrit, gred konkrit G30 memerlukan jumlah penguatan keluli yang lebih besar berbanding gred konkrit G40 iaitu sekitar 12.4% apabila strukturnya dibina di atas tanah jenis C. Oleh itu, jenis tanah dan gred konkrit perlu dipertimbangkan untuk bangunan yang menggunakan reka bentuk seismik.

ABSTRACT

Seismic design is highly developed, complex, and strictly regulated by codes and standards. Seismic codes present criteria for the design and construction of new structures subject to earthquake ground motions in order to minimize the hazard to life and to improve the capability of essential facilities such as hospital building to function after an earthquake. Current practice in Malaysia does not consider seismic design in designing buildings. Health facilities especially hospitals are exposed to risk, serious damage and loss of life during earthquakes, if not appropriately constructed. Since hospital building is one of significant structure for public necessity as a medical institution and need to accommodate lot of people, it must be able to resist seismic load whenever earthquake happen and it is strongly related with the strength of the structure. Hence, this research investigated the amount of steel reinforcement for reinforced concrete (RC) hospital building with seismic design. The analysis conducted by using three different Soil Type and two different Concrete Grade. There are total of eight models of 8 storey RC hospital building used for the analysis designed based on Eurocode 8 and conducted by using Tekla Structural Design software. Based on the result, it can be concluded that the weight of steel reinforcement for beam and column elements increase around 2.3% to 10.8% when compared to the non seismic design when built using Concrete Grade G30. As for the influenced of Concrete Grade, Concrete Grade G30 required larger amount of steel reinforcement compared to Concrete Grade G40 which is around 12.4% when the structure built on Soil Type C. Thus, Soil Type and Concrete Grade should be taken into consideration for seismic building design.

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LIST OF SYMBOLS

α_{gR}	Peak Ground Acceleration
q	Behaviour factor
$\mathrm{M_w}$	Magnitude of earthquake
F_b	Base shear force
$S_{\mathrm{d}}(T)$	Design response spectrum
T_1	Fundamental period
λ	Correction factor
C_{t}	Coefficient
T_{B}	Lower limit of the period of the constant spectral acceleration branch
T_{C}	Upper limit of the period of the constant spectral acceleration branch
T_{D}	Beginning of the constant displacement response range of spectrum
S	Soil factor
α_g	Design ground acceleration
β	Lower bound factor for the horizontal design spectrum
γ_1	Importance factor
q_o	Basic value of behavior factor
K_w	Reflecting factor
M_{Ed}	Bending moment
V	Shear force
P	Axial force
$A_{\mathrm{s,req}}$	Area of steel required

LIST OF ABBREVIATIONS

BS	British Standard
DCH	Ductility Class High
DCL	Ductility Class Low
DCM	Ductility Class Medium
JKR	Jabatan Kerja Raya
NS	Non Seismic
PGA	Peak Ground Acceleration
RC	Reinforced Concrete
SPT	Standard Penetration Test

CHAPTER 1

INTRODUCTION

1.1 Background

Earthquake is one of the natural phenomenon that frequently happen around the world especially at the high seismic region. An earthquake refers to the shaking of the Earth's surface which is resulting from the sudden release of energy in the lithosphere of earth that generates seismic waves. Earthquakes can range in size from those that are so weak that they cannot be felt to those violent enough to toss people around and destroy whole cities. The seismicity or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time.

Fractures and movements within the earth's crust generate earthquake ground motion by sending waves through the rocks and soil outward from the source (Tsai, 2014). These sources are known faults which defined as cracks or weakened planes in the earth's crust most likely to "break" as a result of global tectonic movements. The propagation of the waves through the crust produces movement of the surface of earth. Any one location on the surface will move in every direction simultaneously, back and forth, side to side, and up and down, creating the shaking effect. The shaking effect, or seismic ground motion, is felt in all directions from the epicentre to the location where the fracture started.

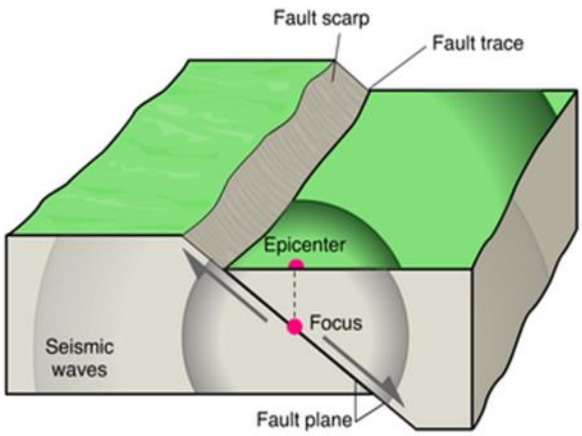

Figure 1.1 Slip of two block of earth during earthquake

(https://kcouse.weebly.com/earthquakes2.html)

According to Marto et al. (2013), Malaysia is considered to have the low seismicity profile and it is located on the Eurasian plate, and closer to the two interpolate boundaries which are the Australian Plates in the west and the Philippines Plate in the east. To date, more evidences are clearly showing that the early assumption Malaysia is free from earthquake is misleading. It is worth mentioning that one of the most significant regional earthquakes which brought catastrophic impacts is the 2004 Indian-Ocean Earthquake with the magnitude of M_w 9.1. This earthquake generated tsunami which devastated the shores of Indian Ocean which cause more than 200,000 people lost their lives (Satake, 2006). Not only this massive and extraordinary geological event had caused deaths and destructions, it had also disturbed the surrounding plate and deformed the core of the Sundaland.

The entire Peninsular has been displaced toward west southwest. The quake caused both co-seismic and post-seismic deformations for the whole of Southeast Asia. Observation of Omar and Jhonny (2009), has indicated that Peninsular Malaysia has experienced the worse deformation than others. Hence, Peninsular Malaysia is now closer to the epicenter and will experience greater impact in future quakes. Geologist have concluded that the initiation of local origin earthquake within Peninsular Malaysia is symptom of reactivation of inactive ancient faults caused by reformation of the Sundaland core as illustrated in Figure 1.2.

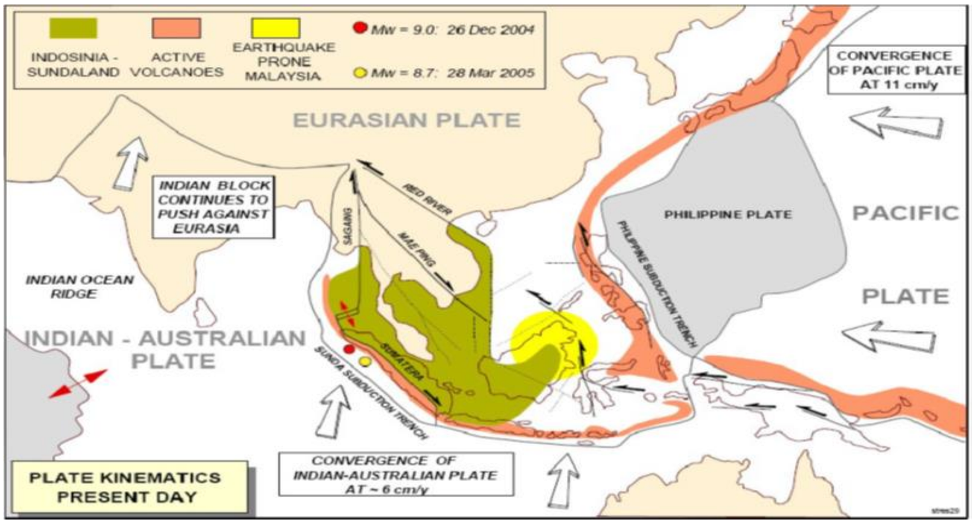

Figure 1.2 Earthquake-prone region of Malaysia (Tjia, 2008)

However, a different scenario has been observed in the East Malaysia. Since 1900 until 2014, at about 70 earthquake events between magnitude M_w 5.0 and above were recorded based on the local earthquakes within East Malaysia where seismic lineaments are not so well defined (Harith et al., 2017). The M_w 6.0 Mt. Kinabalu earthquake occurred at 23:15 UTC, June 4, 2015, within this ambiguous tectonic environment. It was the largest earthquake to strike Sabah province in the past century and came as a surprise to local communities (Wang, 2017).

Both Peninsular and Eastern part of Malaysia had been aware of the seismic hazard and necessities of applying seismic design on new buildings after having affected by the earthquakes. Although Peninsular Malaysia has a very low seismic risk, the damage potential could not be neglected as a large earthquake from neighbouring countries could create considerably ground motion over western part of Peninsular Malaysia. For instance, the earthquakes occurred on the 2nd November 2002, about 500km from Penang, have caused cracks to some buildings in Penang. The moment magnitude and the depth of this earthquake were 7.4 and 33km below the surface, respectively. Other earthquake with magnitude 7.3 occurred on the 25th July 2004 in South Sumatra had caused some cracks to one apartment in Gelang Patah, even though the location of epicenter and the depth of the earthquake were more than 400km from Johor Bahru and 576km below surface, respectively (Adnan, 2015). Based on these two cases, the effects of Sumatra earthquake have to be considered more seriously in Peninsular Malaysia.

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